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[54] CAMERA SYSTEM

[75] Inventors: Masahiro Kawasaki; Hiroyuki Takahashi; Shigeru Iwamoto, all of Tokyo, Japan

[73] Assignee: Asahi Kogaku Kogyo Kabushiki Kaisha, Tokyo, Japan

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[30] Foreign Application Priority Data

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[51] Int. Cl.[5] G03B 3/00

[52] U.S. Cl. 354/195.1

[58] Field of Search 354/400-409, 354/195.1-201, 286

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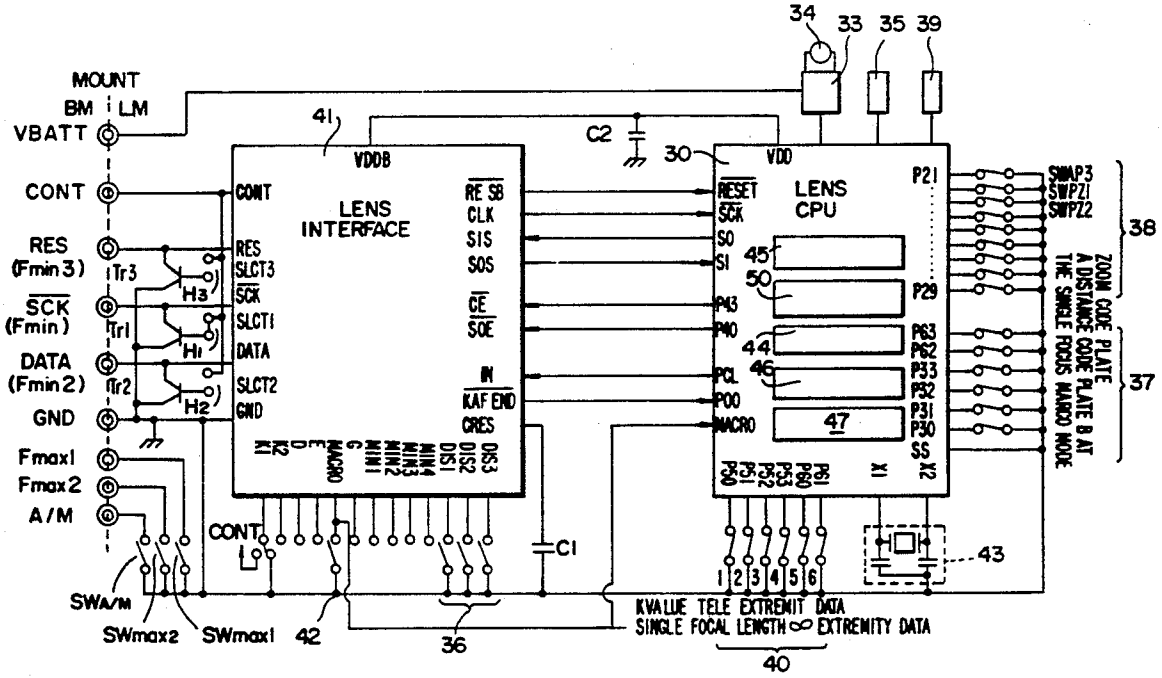
Primary Examiner—Michael L. Gellner
Assistant Examiner—Jae N. Noh
Attorney, Agent, or Firm—Sandler, Greenblum & Bernstein

[57] ABSTRACT

A camera system for communicating data including focal length data between a micro computer in a camera body and a zoom lens mounted to the camera body, wherein the zoom lens includes a position detecting device which detects divided focal length steps corresponding to optional focal lengths of the zoom lens, a specific focal length outputting device which outputs at least one focal length of the focal length step detected by the position detecting device, and an arithmetic operating device which calculates a focal length for each focal length step in accordance with the data of the position detecting device and the specific focal length outputting device.

19 Claims, 6 Drawing Sheets



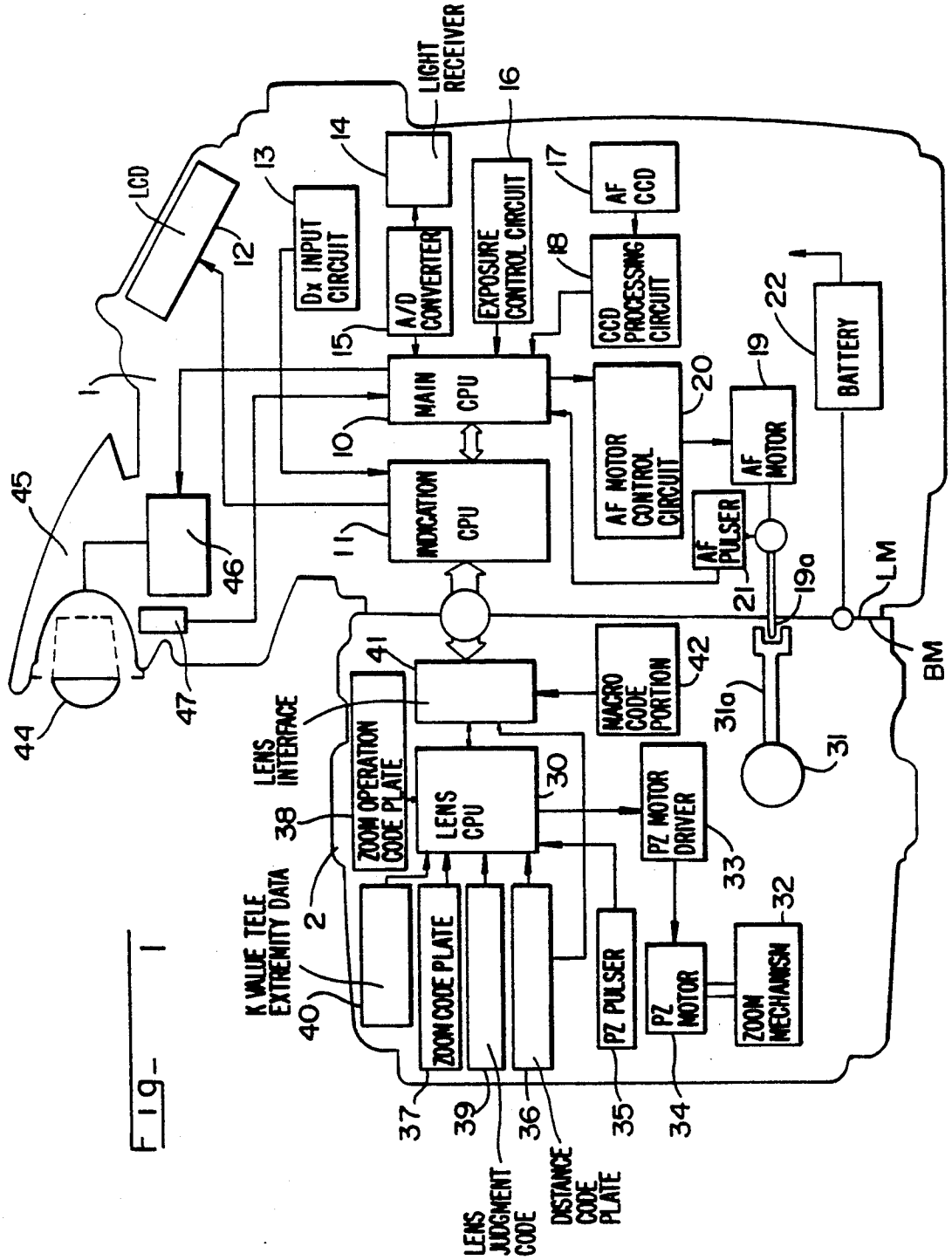

LIGHT RECEIVER
LCD
Dx INPUT CIRCUIT
A/D CONVERTER
EXPOSURE CONTROL CIRCUIT
AF CCD
CCD PROCESSING CIRCUIT
BATTERY
MAIN CPU
INDICATION CPU
AF MOTOR CONTROL CIRCUIT
AF MOTOR
AF PULSER
LM
BM
MACRO CODE PORTION
LENS INTERFACE
ZOOM OPERATION CODE PLATE
LENS CPU
PZ MOTOR DRIVER
K VALUE TELE EXTREMITY DATA
ZOOM CODE PLATE
PZ PULSER
PZ MOTOR
ZOOM MECHANISM
LENS JUDGMENT CODE
DISTANCE CODE PLATE

FIG- 1

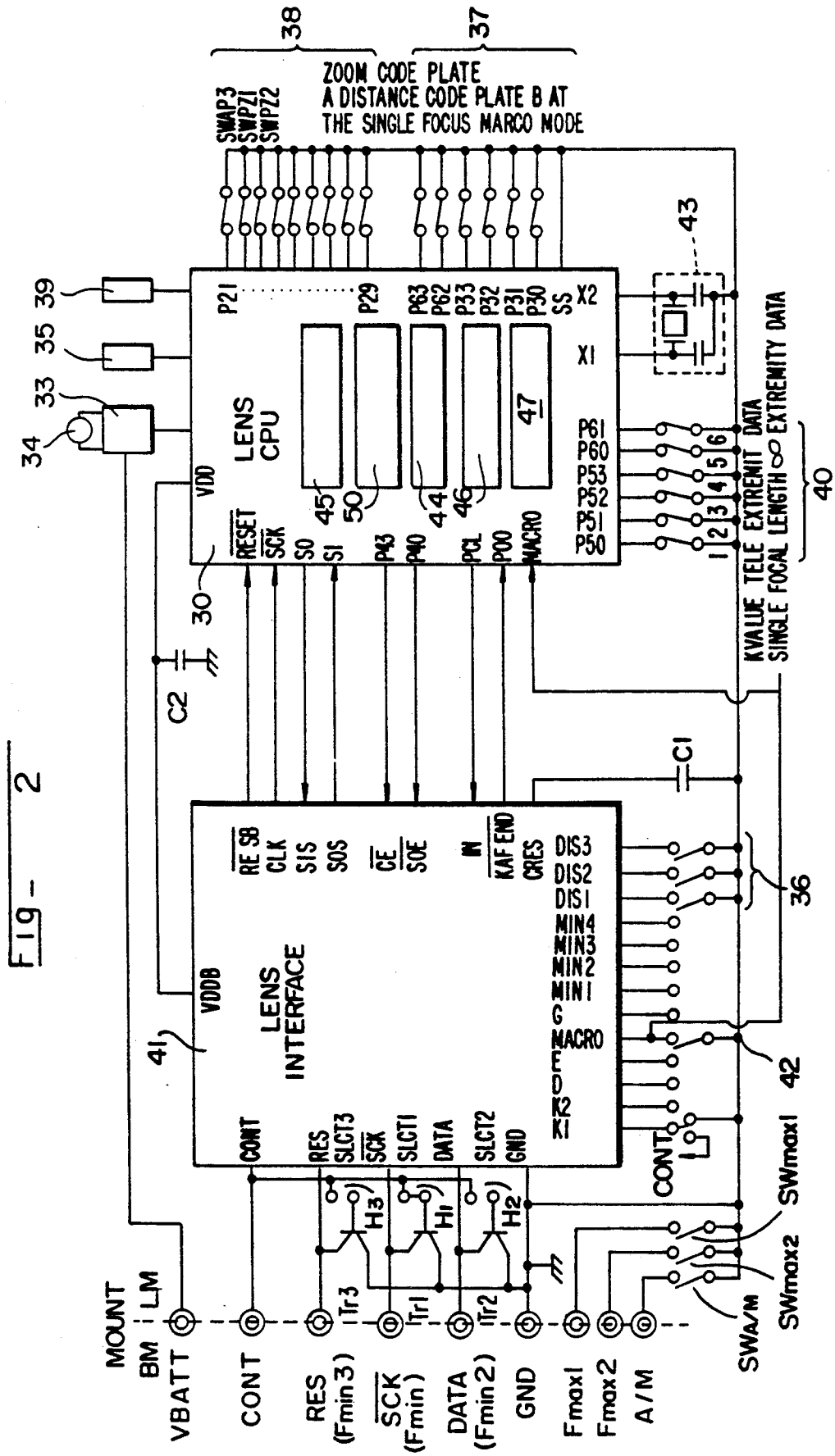

38
37
ZOOM CODE PLATE
A DISTANCE CODE PLATE B AT
THE SINGLE FOCUS MARCO MODE
SWAP3
SWPZ1
SWPZ2
43
LENS
CPU
47
KVALUE TELE EXTREMIT DATA
SINGLE FOCAL LENGTH ∞ EXTREMITY DATA
40
LENS
INTERFACE
41
36
42
SWmax1
SWmax2
SWA/M
MOUNT
BM
LM
VBATT
CONT
RES
(Fmin3)
SCK
(Fmin)
DATA
(Fmin2)
GND
Fmax1
Fmax2
A/M

Fig - 2

Fig. 3

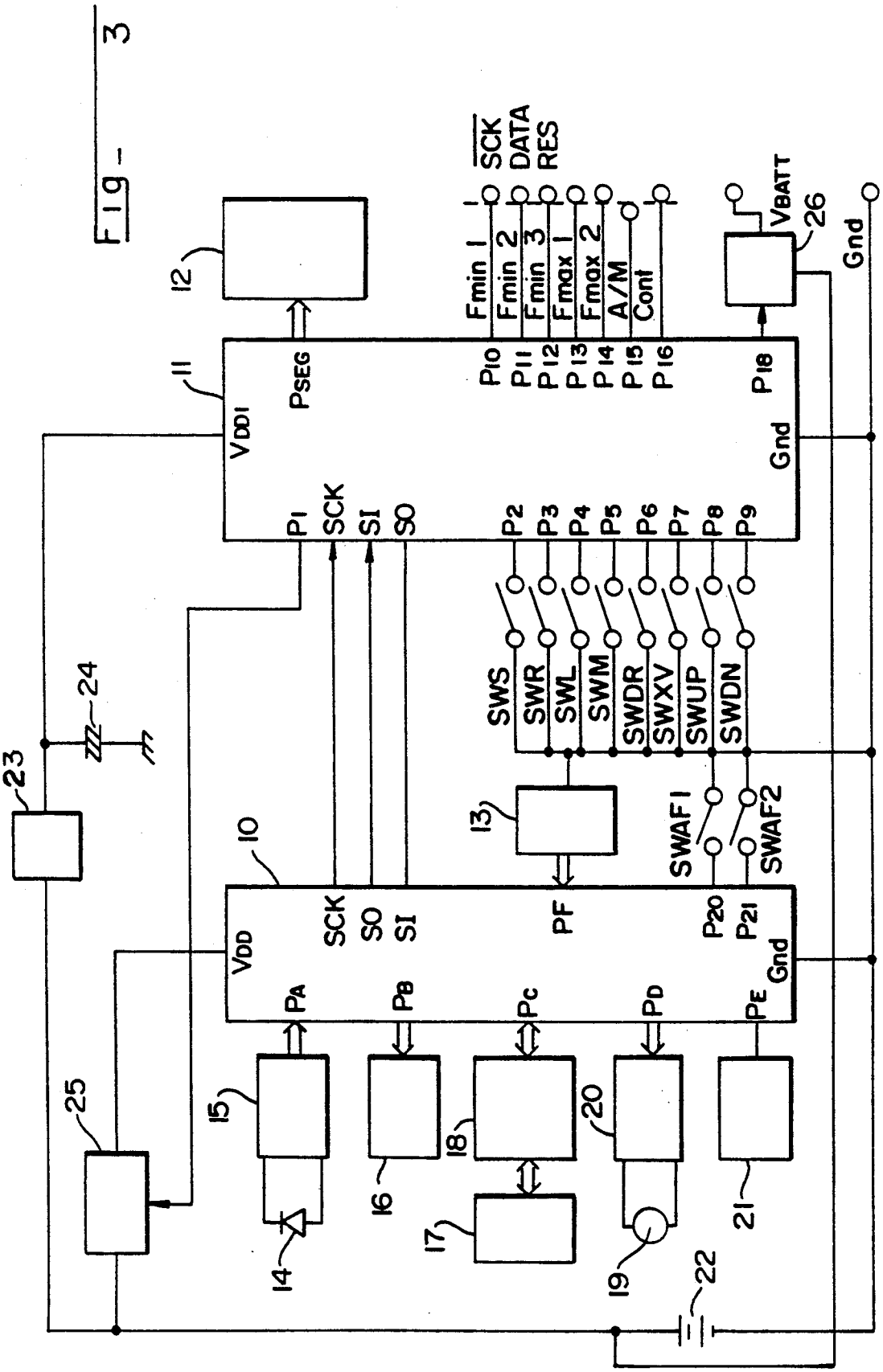

12
11
VDD1
PSEG
SCK
DATA
RES
Fmin 1
Fmin 2
Fmin 3
Fmax 1
Fmax 2
A/M
Cont
P10
P11
P12
P13
P14
P15
P16
VBATT
26
P18
Gnd
P1
SCK
SI
SO
P2
P3
P4
P5
P6
P7
P8
P9
SWS
SWR
SWL
SWM
SWDR
SWXV
SWUP
SWDN
24
23
13
SWAF1
SWAF2
10
VDD
SCK
SO
SI
PF
P20
P21
Gnd
PA
PB
PC
PD
PE
25
15
16
18
20
21
14
17
19
22

Fig. 4

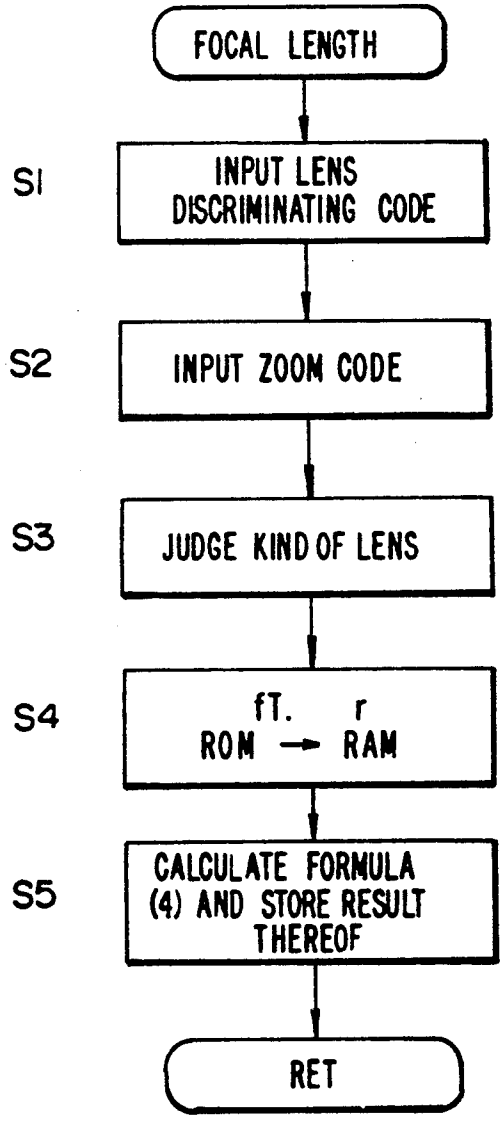

FOCAL LENGTH
S1
INPUT LENS DISCRIMINATING CODE
S2
INPUT ZOOM CODE
S3
JUDGE KIND OF LENS
S4
fT. r
ROM → RAM
S5
CALCULATE FORMULA (4) AND STORE RESULT THEREOF
RET

Fig- 5

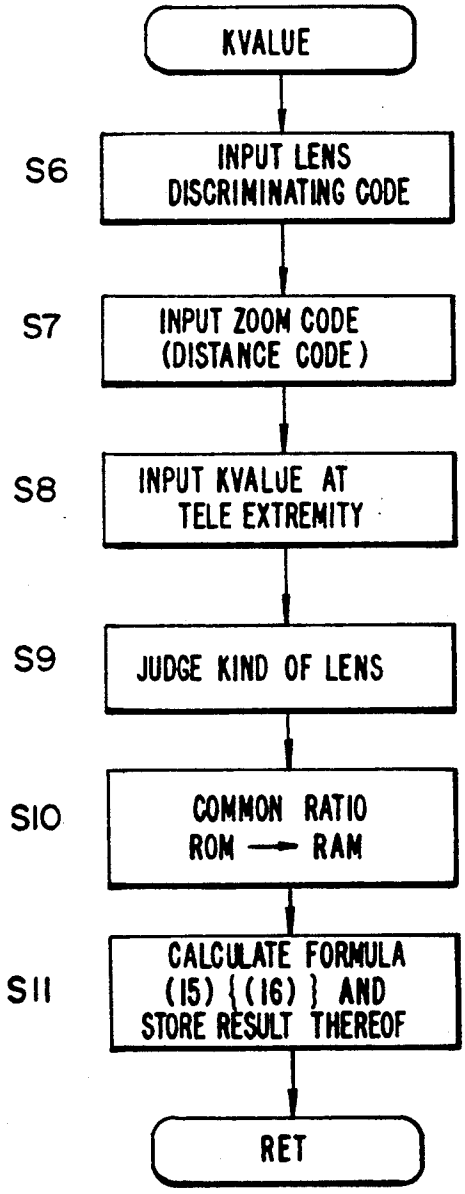

KVALUE
S6
INPUT LENS DISCRIMINATING CODE
S7
INPUT ZOOM CODE (DISTANCE CODE)
S8
INPUT KVALUE AT TELE EXTREMITY
S9
JUDGE KIND OF LENS
S10
COMMON RATIO ROM → RAM
S11
CALCULATE FORMULA (15) {(16)} AND STORE RESULT THEREOF
RET

Fig- 6

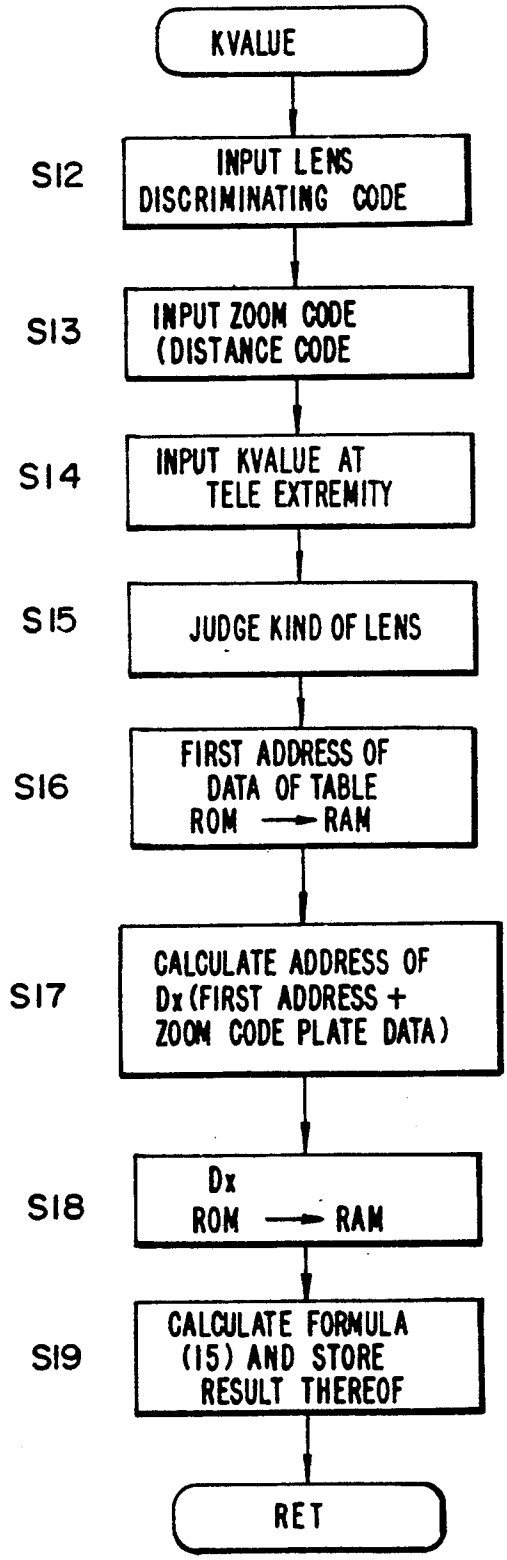
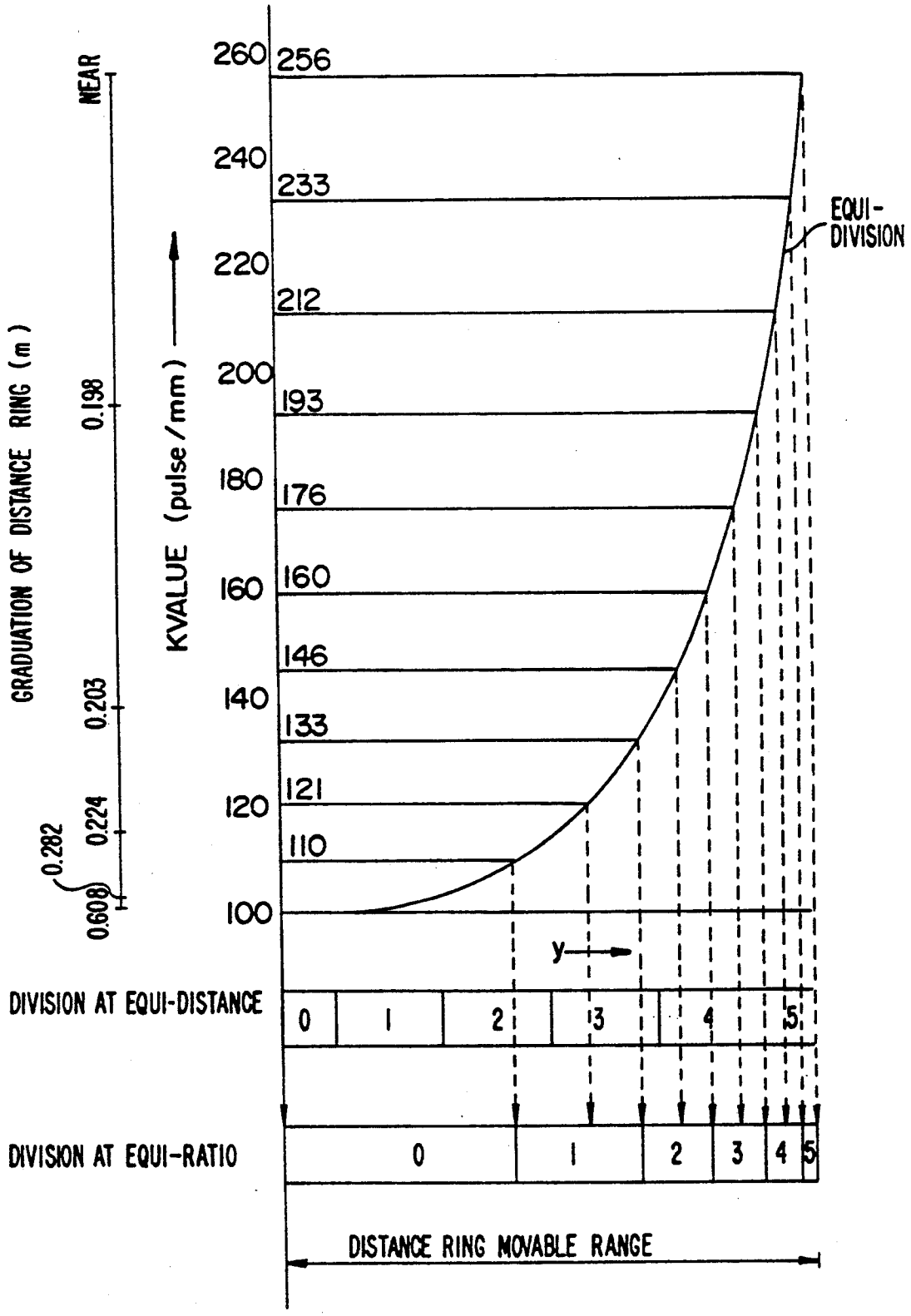

KVALUE
S12
INPUT LENS DISCRIMINATING CODE
S13
INPUT ZOOM CODE (DISTANCE CODE
S14
INPUT KVALUE AT TELE EXTREMITY
S15
JUDGE KIND OF LENS
S16
FIRST ADDRESS OF DATA OF TABLE ROM → RAM
S17
CALCULATE ADDRESS OF Dx (FIRST ADDRESS + ZOOM CODE PLATE DATA)
S18
Dx ROM → RAM
S19
CALCULATE FORMULA (15) AND STORE RESULT THEREOF
RET

Fig - 7


NEAR
0.198
0.203
0.224
0.282
0.608
GRADUATION OF DISTANCE RING (m)
KVALUE (pulse/mm)
260
240
220
200
180
160
140
120
100
256
233
212
193
176
160
146
133
121
110
EQUI-DIVISION
y
DIVISION AT EQUI-DISTANCE
0
1
2
3
4
5
DIVISION AT EQUI-RATIO
0
1
2
3
4
5
DISTANCE RING MOVABLE RANGE

CAMERA SYSTEM

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to a camera system having a data communicator function between a camera body and a photographing lens.

2. Description of Related Art

In a recent single lens reflex camera having an automatic focusing device, information peculiar to a photographing lens, such as open F-number data used in an automatic exposure function or an automatic focusing function is sent as electrical signals from the photographing lens to a CPU (central processing unit) of a camera body.

Information peculiar to the photographing lens is stored in a lens ROM provided in the photographing lens. The photographing lens and the camera body are provided with electrical contacts on a lens mount and a body mount to transmit and receive signal information between the photographing lens and the camera body, respectively. The body CPU transmits and receives signal information to and from the lens ROM through the electrical contacts and reads the data stored in the lens ROM. A clock pulse is output from the camera body to send address signals from the body CPU synchronously therewith, so that predetermined data can be output from the lens ROM in accordance with the address signals.

Furthermore, in a single lens reflex camera having a photographing lens with an AF motor (automatic focusing motor) and a PZ motor (power zoom motor), etc., if control of the motors is effected by the body CPU, there will be an over load on the body CPU. In particular, in a single lens reflex camera in which various kinds of photographing lenses are exchangeably mounted to one camera body, the body CPU must read different parameters depending on the photographing lenses from the associated lens ROM's and perform predetermined arithmetic operations in accordance with the read parameters to control the photographing lenses. This makes quick operations impossible or next to impossible.

In addition to the foregoing, various data, is stored in the ROM of the photographing lens. In particular, in a zoom lens in which a zoom code plate, which comes into sliding contact with brushes provided on a zoom ring when a latter is rotated, has focal length values corresponding to the divided codes of the zoom code plate, the respective focal length values are stored separately in the ROM of the photographing lens. Accordingly, the ROM has to have a large capacity memory. It is necessary to erase the stored necessary data or to troublesomely replace the ROM with a larger capacity ROM in order to write new data therein.

SUMMARY OF THE INVENTION

The primary object of the present invention is to provide a camera system in which the load of operations of a camera body side is reduced, and in which focal length data is not stored in the ROM and can be used in accordance with need.

The basic concept of the present invention resides in that the focal length data is not stored in the ROM and is calculated in accordance with its need.

To achieve the object mentioned above, according to the present invention, there is provided a camera system

for data communication between a micro computer provided in a camera body and a zoom lens mounted to the camera body, wherein the zoom lens transmits at least focal length data to the micro computer of the camera body, wherein the zoom lens comprises a position detecting means for detecting divided focal length steps corresponding to optional focal lengths of the zoom lens, a specific focal length outputting means for outputting at least one specific focal length of the focal length step detected by the position detecting means, and an arithmetic operation means for calculating the focal length for each focal length step in accordance with data of the position detecting means and the specific focal length outputting means.

In this arrangement, the load of operations on the micro computer of the camera body can be reduced, with the arithmetic operation means calculating the focal length data only when it is needed. Accordingly, it is not necessary to continuously store the focal length data in the ROM. Thus, the effective memory (storage capacity) of the ROM can be increased. The focal length data can be easily and accurately calculated when necessary.

The present disclosure relates to subject matter contained in Japanese patent application No. HEI 2-113700 (filed on Apr. 27, 1990) which is expressly incorporated herein by reference in its entirety.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention will be described below in detail with reference to the accompanying drawings, in which:

FIG. **1** is a block diagram of a single lens reflex camera having a camera according to the present invention;

FIG. **2** is a block diagram of a main circuit arrangement of a photographing lens shown in FIG. **1**;

FIG. **3** is a block diagram of the main circuit arrangement of the camera body shown in FIG. **1**;

FIG. **4** is a flow chart of arithmetic operations for determining a focal length of the photographing lens used with the camera of FIG. **1**;

FIG. **5** is a flow chart for arithmetic operations for determining a K value, by way of example;

FIG. **6** is a flow chart for determining arithmetic operations of the K value according to another embodiment of the present invention; and,

FIG. **7** is a diagram showing a relationship between the variation of the K value and the movable range of a distance ring.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

FIG. **1** shows a single lens reflex camera having a camera system according to an aspect of the present invention.

Camera body **1** has a main CPU **10** and an indication CPU **11** (which is collectively referred to as a micro computer). The main CPU **10** generally control the whole camera system and performs arithmetic operations of various data necessary for taking a picture. The indication CPU **11** functions not only as an interface (data communication) to input data by switch members and to transmit and receive data (signals) to and from a photographing lens (zoom lens) **2**, but also as to a controller to control the indication of the photographing data.

The indication CPU **11** is connected to an LCD panel **12** which indicates the photographing data and a DX

code input circuit **13** which selectively reads at least ISO sensitivity data of a film from DX codes provided on a surface of a patrone of the film.

A light receiver **14**, which receives light incident thereon through the photographing lens **2** to output analog signals in accordance with the amount of light received, is connected to the main CPU **10** through an A/D converter **15**.

The main CPU **10** is also connected to an exposure control circuit **16** which drives and controls a shutter mechanism (not shown) and a diaphragm mechanism (not shown), etc., in accordance with the input photographing data, a CCD processing circuit **18** which detects the focusing of the photographing lens **2** in response to the data (focal point data) of an object to be taken, output from an automatic focusing CCD object distance measuring sensor **17**, an AF motor control circuit **20** which drives an AF motor **19** for carrying out the focusing of the photographing lens **2**, and an AF pulser **21** which detects the angular displacement of the AF motor **19** to generate pulses corresponding to the angular displacement. The object distance measuring sensor **17** receives light of the object to be taken. The light is made incident through the photographing lens **2** to output a predetermined focus data signal.

The AF motor **19** transmits the drive power to the photographing lens **2** through a coupler **19***a* provided on a body mount BM of the camera body, so as to be extended from the camera body and a coupler **31***a* provided on a lens mount LM of the photographing lens **2** when the connection between the couplers **19***a* and **31***a* is established.

A battery **22** powers not only electronic components and electronic circuits in the camera body **1**, but also electronic components and electronic circuits in the photographing lens **2**.

In the photographing lens **2** are provided a focusing mechanism **31** which rotates a focus adjusting cam ring (not shown) to move focusing lens groups in an optical axis direction so as to effect a focusing operation, and a zooming mechanism **32** which rotates a zoom ring (not shown) to relatively move at least two groups of variable power lenses in the optical axis direction, so as to effect a zooming operation.

The focusing mechanism **31** is connected to the coupler **31***a*, which is electrically connected to the coupler **19***a* when the photographing lens **2** is attached to the camera body **1**, to transmit the rotational drive of the AF motor **19** to the focusing mechanism **31**. The focusing mechanism **31** rotates the focus adjusting cam ring to affect the focusing. The couplers **19***a* and **31***a* are disconnected by a disengaging means (not shown), so that a photographer can manually rotate a focus adjusting operation ring to adjust the focus in a manual focusing mode.

The zooming mechanism **32** is driven by a PZ (power zoom) motor **34**, which is in turn driven and controlled by a power zoom motor driving portion **33**. The operation of the PZ motor driving portion **33** is controlled in the power zoom mode by the lens CPU **30** or a power zoom switch SWPZ2 (shown in FIG. **2**), and is driven in the manual zoom mode by a manual operation of a photographer. The mode selection between the power zoom mode and the manual zoom mode is controlled by a zoom switch SWZ1 (shown in FIG. **2**). The control is effected by a switching means.

To the input ports of the lens CPU **30** are connected a PZ pulser **35** which detects the displacement of the PZ motor **34**, a distance code plate **36** which reads the position data of the focus adjusting cam ring (focusing lens groups) driven by the focusing mechanism **31** (i.e., it detects the divided focal length steps at a specific focal length), a zoom code plate **37** which reads position data (i.e., focal length data) of the zooming cam ring (variable power lens groups) driven by the zooming mechanism **32**, a zoom operation code plate **38** which inputs data with regard to a direction and speed of the power zooming by the operation of the zoom operation switch, a lens judgement code plate **39** which judges the kind of photographing lens (i.e., zoom lens, single focus lens, or single focus macro lens, etc.) and the data stored in the ROM, and a data setting portion **40** which is made of a code plate and which outputs data on a K value at a telephoto extremity and data on a single focus macro mode at an infinite object distance. In the illustrated embodiment, "K value" (automatic focusing drive pulse coefficient) means a value used for the automatic focusing operation of the lens which can be moved by the AF motor and is the number of pulses of the AF pulser **21** necessary for moving an image plane formed by the photographing lens **2** through a unit displacement (e.g., 1 mm).

The zoom code plate **37** and the other code plates, per se known, are usually made of code plates secured to a cam ring and brushes mounted to a stationary ring with a plurality of electrical contacts which are independently brought into sliding contact with the codes of the code plates. The positions of the cam rings are usually detected as bit information by a combination of the codes with which the electrical contacts of the brushes come into contact. The focal length is divided into a plurality of equidistant focal length steps.

A lens interface **41** is connected to a data input terminal of the lens CPU **30**. The data communication between the lens CPU **30** and the indication CPU **11** is affected through the lens interface **41**, to which a macro code member **42** is connected to input macro data thereto in a macro mode.

The lens CPU **30** performs arithmetic operations to obtain various data, such as a present focal length, a present object distance, etc. The data necessary for the arithmetic operation is stored in an internal ROM (not shown) of the lens CPU **30**.

Circuit of Camera Body

The circuit arrangement of the camera body **1** will be described below in detail with reference to FIG. **3**.

The voltage of the battery **22**, which is controlled by a regulator **23** and which is backed up by a super capacitor **24** is supplied to terminal VDD1 of the indication CPU **11**. The indication CPU **11** is always activated at a constant voltage input to the terminal VDD1.

Terminal P1 of the indication CPU **11** is connected to a DC/DC converter **25**, which turns the power source of the main CPU **10** ON and OFF. In addition photometer switch SWS is selectively connected to the DC/DC converter **25** to be turned ON when a shutter button (not shown) is pressed by a half step. Furthermore, terminals P3 and P4 of the indication CPU **11** are connected to a release switch SWR which is turned ON when the shutter button is fully pressed and a lock switch SWL which is turned ON when the camera is brought into a suitable photographing position, respectively.

The DC/DC converter **25** is actuated when the lock switch SWL is turned ON and when the photometer

switch SWS or the release switch SWR is turned ON, and in accordance with a command from the indication CPU **11** upon inputting the lens data from the photographing lens **2**, to supply terminal VDD of the main CPU **10** with a reference constant voltage to thereby actuate the main CPU **10**.

Furthermore, terminals **P5**, **P6**, **P7**, **P8** and **P9** of the indication CPU **11** are connected to a mode switch SWM, a drive switch SWDR, and exposure correction switch SWXV, an up-switch SWUP and a down-switch SWDN, respectively.

The indication CPU **11** operates in accordance with the operative and inoperative states of the switches SWM, SWDR, SWXV, SWUP, and SWDN. For instance, the exposure modes, which includes a programed exposure mode, an automatic exposure mode, and a manual exposure mode, are selected in accordance with the operation of the mode switch SWM. Similarly, drive modes, which includes a single shot mode and a continuous shot mode, are selected in accordance with the operation of the drive switch SWDR. The selection modes can be varied in accordance with the operation of the up-switch SWUP and down-switch SWDN at the position in which the exposure modes or the drive modes can be selected.

The indication CPU **11** makes it possible to change the exposure value when the exposure switch SWXV is turned ON. Namely, the exposure value can be increased and decreased in accordance with an operation of the up-switch SWUP and the down-switch SWDN, respectively.

The indication CPU **11** has a group of indication control terminals PSEG that are connected to an indicating LCD **12** through a bus line. The indicating LCD **12** indicates necessary photographing data in accordance with commands of the indication CPU **11** when the lock switch SWL is turned ON.

Seven terminals **P10** through **P16** of the indication CPU **11** are connected to electrical contacts **Fmin1**, **Fmin2**, **Fmin3**, **Fmax1**, **Fmax2**, **A/M**, and **Cont** provided on the body mount BM of the camera body, respectively. Terminal **P18** of the indication CPU **11** is connected to a switch circuit **26**.

The electrical contacts **Fmin1**, **Fmin2** and **Fmin3** function as communication terminals for data communication between the photographing lens **2** and the indication CPU **11**. Namely, the electrical contacts **Fmin1**, **Fmin2** and **Fmin3** constitute a serial clock signal inputting and outputting terminal $\overline{SCK}$, a data transmitting and receiving terminal DATA, and a reset signal outputting terminal RES, respectively.

Terminals **P10**, **P11** and **P12** of the indication CPU **11** are always pulled up within the indication CPU **11**.

The output of the switch circuit **26** is connected to a terminal VBATT and functions as a switch for establishing and breaking an electrical connection between the battery **22** and the terminal VBATT in accordance with the level of the terminal **P18**. Terminal Gnd of the indication CPU **11** is connected to ground terminal Gnd of the battery **22**.

The indication CPU **11** and the main CPU **10** communicate with each other through serial terminals SCK, serial-in terminals SI and serial-out terminals SO. In conventional data communication, data is transferred using command codes, as shown in Table 1 below. In Table 1, the left column represents data which is output from the indication CPU **11** to the main CPU **10**, and the right column represents data which is transferred from the main CPU **10** to the indication CPU **11**. This data is set based on the measurements of the object luminance and the object distance, etc. controlled by the main CPU **10**.

TABLE 1

Indication CPU 11 → Main CPU	Main CPU 10 → Indication CPU
Mode Setting Data	Indication Tv, Sv data
Drive Setting Data	Film Sensitivity Data
Exposure Correction Setting Data	AF Accomodation Pulse No. Data
Lens CPU Data	AF Return Completion Data
Setting TV, SV Data	
AF Accommodation Data	
AF Return Code	
AF Return Pulse No. Data	
AF Accommodation and Return Codes	

Contact groups PA, PB, PC, PD, PE and PF of the main CPU **10** are connected to an A/D converter **15**, the exposure control circuit **16**, the CCD processing circuit **18**, the AF motor control circuit **20**, the AF pulser **21**, and the DX code input circuit **13**, respectively.

Terminal **P20** of the main CPU **10** is connected to a first AF switch **SWAF1**, which selects an auto focus mode in which focusing is automatically affected by the AF motor **19** and a manual focus mode in which focusing is manually affected by a photographer. Terminal **P21** of the main CPU is connected to a second AF switch **SWAF2**, which switches the mode of the shutter release between a focus priority mode and a release priority mode. The first and second AF switches **SWAF1** and **SWAF2** are mechanically associated with each other, so that, for example, when the manual focus mode is selected by the first AF switch **SWAF1**, and second AF switch **SWAF2** is switched to the release priority mode. Namely, when the first AF switch **SWAF1** is turned ON, the second AF switch **SWAF2** is turned OFF.

Circuit of Photographing Lens

The circuit arrangement of the electrical system provided in the photographing lens **2** will be explained below, with reference to FIG. **2**.

The lens mount LM of the photographing lens **2** is provided with electrical contacts VBATT, CONT, RES (**Fmin3**), $\overline{SCK}$ (**Fmin1**), DATA (**Fmin2**), GND, **Fmax1**, **Fmax2** and **A/M** corresponding to associated electrical contacts provided on the body mount BM when the photographing lens **2** is attached to camera body **1**. Although the arrangement of the electrical contacts of the lens mount LM is not identical to that of the body mount BM, for the purpose of clarification, the electrical contacts of the lens mount designated are electrically connected to the corresponding electrical contacts of the body mount with the same reference numerals.

Contact VBATT on the lens side is connected to the PZ driver **33**, so that the power of the battery **22** is directly supplied to the PZ motor **34** through the contact VBATT by the switching operation of the PZ driver **33**.

Contact Fmax1 and Fmax2 on the lens side function also as a steady information transmitting means for transmitting the maximum F-number data of two bits to the camera body, similar to those provided on a conventional AE lens. Namely, the contacts Fmax1 and Fmax2 on the lens side are grounded through the switches SWmax1 and SWmax2, so that maximum F-number (minimum diaphragm value) data is formed in accordance with a combination of the levels of the switches SWmax1 and SWmax2 depending on the ON/OFF states thereof. The combinations of the levels of the contacts Fmax1 and Fmax2 on the lens side and the maximum F-number are shown in Table 2 below.

TABLE 2

F NO.	Fmax2	Fmax1
22	0	0
32	0	1
45	1	0

The contact A/M on the lens side functions to send the auto/manual information of the diaphragm to the camera body **1** and is grounded through a selection switch SWA/M. The selection switch SWA/M is in association with the rotation of a diaphragm ring (not shown) of the photographing lens **2**, so that when the diaphragm ring is in the auto position and the manual position, the selection switch is turned ON and OFF, respectively.

Contacts Fmin1, Fmin2, and Fmin3 on the lens side function not only as a steady information transmitting means for transmitting the open (minimum) F-number information of three bits to the camera body **1**, similarly to those provided on an existing (old) AE lens, but also as data communication contacts between the camera body and the photographing lens. The relation between the levels of the contacts Fmin1, Fmin2 and Fmin3 on the lens side and the minimum F-number is shown by example in Table 3 below.

TABLE 3

F NO.	Fmin3	Fmin2	Fmin1
1.4	0	0	0
1.7	0	0	1
2	0	1	0
2.5	0	1	1
2.8	1	0	0
3.5	1	0	1
4	1	1	0
4.5	1	1	1

To provide both the steady information transmitting function and the data communication function on the contacts Fmin1, Fmin2 and Fmin3 on the lens side, the contacts are connected to PNP transistors Tr1, Tr2 and Tr3, respectively. The PNP transistors Tr (Tr1, Tr2 and Tr3) are connected at the emitters thereof to the lens contacts Fmin1, Fmin2 and Fmin3, and at the bases thereof to the contact CONT through fuze portions H1, H2 and H3 so as to establish and break the connection, respectively. The collectors of the transistors are grounded. It is possible to provide the fuse portions H1, H2 and H3 between the emitters and the lens contacts Fmin (Fmin1, Fmin2 and Fmin3).

The indication CPU **11** causes the voltage of the contact CONT to drop to ground in order to obtain the open F-number data from the lens contacts Fmin1, Fmin2 and Fmin3. As a result, any transistor Tr to which the fuse portion is connected is turned ON, so that the emitter of the affected transistor which has been turned ON becomes a high level "H", and the emitter of the transistor which has not been turned ON becomes a ground level. Namely, the transistors Tr are selectively made ON or OFF in accordance with the connection of the fuse portions H1, H2 and H3 to change the level of the emitters thereof. Consequently, the three-bit open F-number data is output to the lens contacts Fmin1, Fmin2, and Fmin3.

Terminals CONT, RES, $\overline{SCK}$, DATA and GND of the lens interface **41** is connected to the terminals CONT, Fmin3, Fmin1, Fmin2 and GND on the lens side, respectively.

The lens contact CONT is connected to the bases of the transistors Tr and to the terminal CONT of the lens interface **41**, as mentioned above. The switching of the power supply from the terminal CONT of the lens interface is affected through the lens terminal Fmin3. After the data on the open F-number is transferred, when the terminals CONT and RES (lens terminal Fmin3) become levels "H" and "L", respectively, the power is supplied to the lens CPU **30**.

Terminal VDDB of the lens interface **41** is connected to terminal VDD of the lens CPU through a capacitor C2, so that a constant voltage supplied from terminal CONT of the camera body **1** is supplied to the lens CPU **30**.

Terminals DIS1, DIS2 and DIS3 of the lens interface **41** are connected to distance code plate **36**, so that distance data signals of the object distance corresponding to the position of the focusing cam ring driven by the focusing mechanism **31** are input to the terminals DIS1, DIS2 and DIS 3.

Terminal MACRO of the lens interface **41** is connected to macro code portion **42**, which functions as a macro switch, which is turned ON when the zoom operation ring is actuated to switch the photographing lens **2** to the macro mode.

The input and output terminals of the lens interface **41** are connected to corresponding input and output terminals of the lens CPU **30**. Reset terminal $\overline{RESB}$, clock terminal CLK, serial-in terminal SIS, serial-out terminal SOS, terminal $\overline{CE}$, terminal $\overline{SOE}$, terminal ϕ IN, and terminal $\overline{KAFEND}$, of the lens interface **41** are connected to reset terminal $\overline{RESET}$, serial clock terminal $\overline{SCK}$, serial-out terminal SO, serial-in terminal SI, terminal P43, terminal P40, terminal PCL and terminal POO of the lens CPU **30**, respectively. Terminal CRES of the lens interface **41** is grounded through a delay capacitor C1.

The lens CPU **30** controls the PZ driver **33** connected to the control terminal thereof. The lens CPU **30** is also connected to the PZ pulser **35** and the lens discriminating code **39**, which outputs data with regard to the lens type (i.e., old lens, new lens, etc.).

Terminals P30, P31, P32 and P33 and terminals P62 and P63, of the lens CPU **30** are connected to codes of the zoom code plate **37** (position detecting means). The zoom code plate **37** functions as a distance code plate B at the single focus macro mode.

Terminals P21 through P29 are connected to various switches, including the automatic focusing switch SWAF and the power zoom switches SWPZ1 and

SWPZ2, etc. Terminals P50 through P53, P60 and P61 of the lens CPU 30 are connected to the data setting portion 40.

The lens CPU 30 includes a lens judging means 45, a data storing means 46, a data table 47, a telephoto extremity focal length storing means 50, and an arithmetic operating means 44.

The lens judging means 45 determines whether lens or a single focus micro lens etc., in accordance with the data an old lens or a new lens, and a zoom lens, a single focus of the lens discriminating code 39. An old lens does not have a lens CPU. On the other hand, a new lens contains a lens CPU therein . A new lens is illustrated in FIGS. 1 and 2.

The data storing means 46 stores a common ratio and a common difference for geometrically and arithmetically dividing the focal length range of the photographing lens 2.

Coefficient data $(r^x)^2$ necessary for calculating a K VALUE corresponding to the photographing lens is prestored in the data table 47, as shown in Tables 1 and 2.

The telephoto extremity focal length storing means 50 stores the focal length of the photographing lens at the telephoto extremity.

The arithmetic operating means 44 calculates the focal lengths and the drive pulse coefficient K VALUE's at respective focal length steps upon zooming, in accordance with the determination of the lens by the lens judging means 45, the levels of the terminals P30 through P33, P62 and P63, the K VALUE of the data setting portion 40 at the telephoto extremity, and the K VALUE at the single focus macro mode, and stores the calculated data in a RAM.

The photographing lens 2 has a clock pulse generating circuit 43 which is connected to clock terminals X1 and X2 of the lens CPU 30. The lens CPU 30 operates synchronously with the clock pulses generated by the clock pulse generating circuit 43.

As mentioned above, on the camera body side, after terminal CONT drops to level "L" and the open F-number is read, both terminals CONT and RES (Fmin3) become level "H" to reset the lens CPU 30.

When the reset is released, the lens CPU 30 begins the old communication in accordance with the clock pulses of the camera body 1. This communication is carried out by hardware of the lens interface 41. In the illustrated embodiment, data for 19 bytes is sent to the camera body 1.

Upon completion of the communication, terminal $\overline{\text{KAFEND}}$ of the lens interface 41 becomes a level "L", which is a communication completion signal. Consequently, the lens CPU waits for renewal data of the communication from the camera body 1.

When the lens CPU 30 receives the renewal communication data from the camera body 1, terminal DATA (Fmin2), which has been at level "H", becomes a level "L" and then becomes level "H" again, so that the camera body can commence the new communication. Note that the states of terminals CONT and RES are held when the lens CPU 30 is first activated.

The new communication which commences upon completion of the old communication is carried out directly between the lens CPU 30, the indication CPU 11 and the main CPU 10 without the lens interface 41. The data is transmitted from the lens CPU 30 to the main CPU 10 and the indication CPU 11, or from the main CPU computer 10 and the indication CPU 11 to the lens CPU 30, in accordance with the command code of the indication CPU 11. An example of the data communication between camera body 1 and photographing lens 2 is shown in Table 4.

The new data communication is affected synchronously with the clock pulse output from the photographing lens 2.

TABLE 4

Lens → Camera Body		
AF Data	0011.0001	(31H)
AE Data	0011.0010	(32H)
All Data	0011.0011	(33H)
Every One Byte	1010.XXXX	(5XH)
Lens Data 1	0110.0000	(60H)
Lens Data 2	0110.0001	(61H)
Camera Body → Lens		
Focal Length Data fWide	0110.0010	(62H)
Focal Length Data fTele	0110.0011	(63H)
Focal Length Data fX(present)	0110.0100	(64H)
Lens Drive Data	0110.0110	(66H)
Lens Accommodation	1001.0010	(90H)
Lens Return	1001.0001	(91H)
PH ON	1001.0010	(92H)
PH OFF	1001.0011	(93H)

	Lens Data 1 60H	Lens Data 2 61H	Lens Drive Data 66H
Bit 7	PH Demand	Lens CPU	fW extremity
Bit 6	AF A/M		fT extremity
Bit 5	PZ A/M	Lens Internal PZ	
Bit 4	PZ P/A		
Bit 3	PZ MODE		PZ Far
Bit 2	SET SW		PZ Near
Bit 1	Lens A/M	Lens	
Bit 0	Lens O/C	Version	

Calculation of Focal Length

The following discussion will be directed to the arithmetic operating means calculation of focal length in both the zooming and macro modes.

First, a zooming ratio R of the photographing lens 2, used to geometrically divide the code of the distance code plate 37 (distance code plate B) into n-codes, is obtained by the following equation:

$$R=f_T/f_W \tag{1}$$

wherein f_T designates a focal length at a telephoto extremity and f_W designates a focal length at a wide angle extremity, respectively.

Then, a common ratio r satisfies the following equation when the code of the zoom code plate 37 of the photographing lens 2 is geometrically divided into n-codes with reference to the telephoto extremity:

$$R=r^{n-1} \tag{2}$$

From equation (2) above, we have;

$$r=\sqrt[n-1]{R} \tag{3}$$

Accordingly, focal length fx at a position x of the zoom ring ($0 \leqq x \leqq n-1$, where "0" designates the telephoto extremity and "n−1" designates the wide angle extremity) is determined by the following equation:

$$f_x=f_T/r^x \tag{4}$$

Since the zoom code plate 37 (distance code plate B) corresponding to the zoom ring position x has a certain

width (band) of code in which there is no change of code, in case of slight angular displacement of the zoom ring, it is necessary to geometrically position the focal length f_x corresponding to the zoom ring position x at an intermediate position of the zoom code plate **37**. To this end, changing points of the zoom code plate **37** are obtained as follows:

$$f_{x-x+1}=f_T/r^{x+0.5} \quad (5)$$

wherein f_{x-x+1} is a focal length at a changing point between a zoom code position x and a zoom code position (x+1) adjacent thereto.

Since the calculation is carried out by the arithmetic operating means **44**, the memory of the ROM can be reduced in comparison with the memory of the ROM in which the focal lengths for every divided code by the zoom code plate **37** (distance code plate B) must be stored.

Upon arithmetically dividing the zoom code plate **37** into n-codes, a common difference d can be obtained as follows:

$$f_{dif}=f_T-f_W \quad (6)$$

$$\therefore d=f_{dif}/(n-1) \quad (7)$$

$$f_x=f_T-d_x \quad (8)$$

wherein f_{dif} designates the actual amount of zooming, f_T the focal length at the telephoto extremity.

Therefore, the changing point can be obtained by the following equation:

$$f_{x-x+1}=f_T-d(x+0.5) \quad (9)$$

This will be explained below with reference to a flow chart of the operations shown in FIG. **4**.

In step **S1**, the lens CPU **30** receives a discrimination code is inputted thereto for discriminating the kind of mounted lens from the lens judging code plate **39**.

Thereafter, the zoom code data corresponding to the optional zoom ring position x is inputted from the zoom code **37** (distance code plate B) to the lens CPU **30**, in step **S2**.

In step **S3**, the lens judging means **45** determines whether the photographing lens mounted to the camera body **1** is an old lens or a new lens, or a zoom lens, a single focus lens or a single focus macro lens, in accordance with the data of the lens judging code plate **39**.

Thereafter, in step **S4**, the data of the focal length "f_T" in the telephoto extremity and the common ratio "r" thereof are sent to the RAM from the telephoto extremity focal length storing means **50** in accordance with the determination of the lens judging means **45**. Although the focal length "f_T" at the telephoto extremity is used as data for calculation, it is possible to use the focal length in the wide angle extremity, or any reference focal length other than those in the telephoto extremity and the wide angle extremity.

In step **S5**, the arithmetic operating means **44** calculates the focal length which is geometrically (or arithmetically) divided correspondingly to the lens, in accordance with the data obtained in step **S4**, based on equation (4) mentioned above, and the calculation result obtained is stored in the RAM. The calculated data of the focal length is directly transmitted as new communication to the main CPU **10** and the indication CPU **11** without going through the lens interface **41**.

Calculation of K VALUE at Zooming

The calculation of the K value (automatic focusing drive pulse coefficient) used in the zooming operation is performed by the arithmetic operating means **44**.

In the following description, "K" designates the K value at a focal length F, "G" designates a gear ratio of the focusing mechanism **31** in the photographing lens **2**, "P" designates a number of pulses when the coupler **19***a* on the camera body side rotates by one turn, "L" designates a lead (mm) of a focusing helicoid, i.e., the displacement when the helicoid rotates by one turn, "F" designates a FL conversion coefficient, i.e., the ratio between a displacement of the lens and a displacement of the image plane, and "f_T" designates a focal length at the telephoto extremity.

The K value "K" can be obtained by the following equation:

$$K=\frac{G\times P\times F}{L} \quad (10)$$

Since the photographing lens **2** is a zoom lens, the focal length "F" is determined by the following formula:

$$F=\left(\frac{f_T}{f_x}\right)^2 \quad (11)$$

wherein f_x is the focal length at the position x of the zoom ring, and f_T is focal length at the telephoto extremity.

From equations (10) and (11), the K value "K_x" at the zoom ring position x (the x-th focal length step from the telephoto extremity) is obtained by formula (12):

$$K_x=\frac{G\times P\times\left(\frac{f_T}{f_x}\right)^2}{L} \quad (12)$$

K value "K_T" at the telephoto extremity is obtained by the following equation (13):

$$K_T=\frac{G\times P\times 1}{L} \quad (13)$$

From equations (12) and (13) mentioned above, we have:

$$K_x=K_T\times\left(\frac{f_T}{f_x}\right)^2 \quad (14)$$

From equations (14) and (4), "K_x" in a geometrical division and an arithmetic division can be obtained by the following equation, respectively:

$$K_x=K_T\times(r^{-x})^2 \quad (15)$$

$$K_x=K_T\times\left(\frac{f_T}{f_T-d_x}\right)^2 \quad (16)$$

When the K value is determined in accordance with equation (15) and (16), two methods are used: (a) the common ratio is directly used as data for calculation,

and (b) the coefficient obtained based upon the common ratio is prestored in the ROM (data table 47) as data corresponding to each code step of the zoom ring position, so that the stored data is fetched from the data table 47 to calculate the K value.

The first method (a) mentioned above will be first explained below, with reference to the flow chart of FIG. 5.

In step S6, the discrimination code is input from the lens judging code plate **39** to discriminate the kind of lens. Thereafter, the zoom code (or the distance code in the case of a single focus macro lens) in the zoom ring position x (the x-th focal length step from the telephoto extremity) is input from the zoom code plate **37** (i.e., the distance code plate B).

In step S8, the k value at the telephoto extremity (or infinite object distance in the case of a single focus macro lens) is inputted.

Thereafter, the lens judging means **45** determines the kind of photographing lens, in accordance with the lens discrimination code from the lens judging code plate **39** (step S9).

In step S10, the common ratio "r" (or "a" in the case of a single focus macro lens, which is discussed in detail below) corresponding to the photographing lens mounted to the camera body **1** is transferred to the RAM from the data storing means **46**.

Thereafter, the arithmetic operating means **44** calculates the k value at the zoom ring position x, based on formulate (15) and (16) in step S11. The calculated data is stored in the RAM. Thereafter, control returns. This means that the calculation of the K value "K_x" is in accordance with the K value "K_T" which is steady data inputted from the CPU port (pin) in the telephoto extremity, the common ratio "r" which is ROM data in the lens CPU **30**, and the steady data "x" of the zoom code plate.

The data "K_x" obtained is directly sent to the main CPU **10** and the indication CPU **11** as new communication without going through the lens interface **41**. The CPU **10** controls the photographing lens **2** in accordance with the data "K_x" input thereto.

On the other hand, in the case of method (b) mentioned above, the discrimination code is inputted from the lens judging code plate **39** to determine the kind of photographing lens **2**, in step S12, shown in FIG. **6**.

In step S13, the zoom code (or the distance code in the case of a single focus macro lens) in the zoom ring position is inputted from the zoom code plate **37**.

In step S14, the k value in the telephoto extremity (or infinite object distance the case of a single focus macro lens) is input from the data setting portion **40**.

Thereafter, the lens judging means **45** determines the kind of photographing lens in accordance with the lens discrimination code from the lens judging code plate **39** in step S15.

In steps S16 and S17, the data table (Table 5 or 6) to be used is selected, and the first address (or the first address+zoom code plate data in the case of a single focus macro lens) of the data "D_x" of the required value "$(r^x)^2$" is calculated. The value "D_x" is fetched from the selected data table and is stored in the RAM in step S18.

Thereafter, the arithmetic operating means **44** calculates the drive pulse coefficient K value, based on equation (10) in step S19. The calculated data is stored in the RAM. Thereafter, control returns. Namely, a predetermined number of parts "$(r^x)^2$" of the equation (150 corresponding to number of the divided focal lengthsteps of the zoom ring is only stored in the ROM as a table data so as to selectively use the data, depending on the kind of photographing lens mounted to the camera body.

The calculation method (b) mentioned above will be explained below in more detail, with reference to the calculation of the K value, based on a 4 bit signal inputted from the zoom code plate **37**, by way of examples. In the examples below, the data tables are divided into 16 ($2^4=16$) segments Note that $r-1.09375$ in Table 5 and $r=1.125$ in Table 6. The four bit signals are inputted from the zoom code plate **37**. In the embodiments, the K value is calculated from the four bit signals, meaning that a maximum of 16 (2^4-16) different data can be recorded. Thus, Tables 5 and 6 are divided into 16 parts. However, it is not necessary to always use all 16 data, since an exchanged-photographing lens requires a different amount of data, just up to the minimum amount necessary for the zooming ratio of the lens.

In the case of "a photographing lens having a zoom ratio of 3", the value "(r^x) in equation (15) for Table 5 in which $r-1.09375$ is as follows:

In Formula (15), $K_x=K_T x(r^x)^2$. Using the known value K_T, which corresponds to the x-th from "0" in Table 5, one can calculate the K value. The procedure is to find the value of "x" that is infinitely close to "3" (the zoom ratio of the lens). In other words, $(r^{x2}\approx 3^2$. As a result, $(r^{12})^2\approx(2.95)^2\approx(3)^2$. As shown in (r^{12}), the data from 0 to 12th in Table 5, which corresponds to 13 different data, are sufficient for a photographing lens having a zoom ratio of 3.

Consequently, the zoom code is divided into 13 segments.

In the case of "a photographing lens having a zoom ratio of 4", the value "(r^x) in formula (150 for table 6 in which $r-1.125$ is as follows.

In formula 15, $K_x=K_T x(r^x)^2$. Using the known value K_T, which corresponds to the x-th from "0" in Table 6, one can calculate the k value. The procedure is to find the value of "x" that is infinitely close to "4" (which is the zoom ratio of the lens). In other words, $(r^x)^2\approx 4^2$. As a result, $(r^{12})^2\approx(4.11)^2\approx(4)^2$. As shown in (r^{12}), the data from 0 to 12th in Table 6, which corresponds to 13 different data, are sufficient for a photographing lens having a zooming ratio of 4.

Consequently, the zoom code is divided into 13 segments. Namely, when the value K_x is calculated, based on the telephoto extremity K value and the value D_x which are port data k_T of the micro computer, based on equation (15), the following equation is satisfied.

$$K_x=K_T\times M_x \tag{17}$$

wherein M_x is ROM data at position x.

TABLE 5

ADDRESS1	r=1.09375
0	1.09375^0
1	1.09375^2
2	1.09375^4
3	.
4	.
5	.
6	.
7	.
8	.
9	.
10	.
11	.
12	.

TABLE 5-continued

ADDRESS1	r=1.09375
13	.
14	.
15	.

TABLE 6

ADDRESS2	r=1.125
0	1.125^0
1	1.125^2
2	1.125^4
3	.
4	.
5	.
6	.
7	.
8	.
9	.
10	.
11	.
12	.
13	.
14	.
15	.

Calculation of K value in Single Focus Macro Lens

There are two methods of calculation of the K value by the arithmetic operating means **44**, similar to the case of the zooming mentioned above. In the following example, the object distance code is geometrically divided into n-codes.

The common ratio "a" is given by the following formula:

$$a = \sqrt[2(n-1)]{\frac{K_N}{K_\infty}} \quad (18)$$

wherein "K_N" is a K value at a NEAR extremity of a macro lens, and "K_∞" is a K value at an infinite object distance.

The common ratio "a" is stored in the data storing means **46** of the lens CPU **30** and is outputted to the antithetic operating means **44** at an address designated upon calculation of the K value.

When the code of the distance code plate B is geometrically divided into n-codes, the K value "Ky" at an optional object distance "y" ($0 \leqq y \leqq n-1$) of the macro lens is obtained by the following formula:

$$Ky = K_\infty \times (a^y)^2 \quad (19)$$

The example below is directed to a 2.8/50 mm macro lens mounted to the camera body **1**, in which the code of the distance code plate B is divided into 6 codes.

FIG. **7** shows a diagram in which an abscissa represents a code number of the distance code plate B which is equally divided into six (No. 0 through 5), and an ordinate, is divided into the K value, and the position "y" (object distance) of the distance ring corresponding thereto.

If Kn=256, K_∞=100, N=6, we have from equation (18):

$$a = \sqrt[2(6-1)]{\frac{256}{100}}$$

-continued

$$= 1.09856 \text{ (common ratio)}$$

The common ratio (1.09856) which is stored in the data storing means **46** is outputted to the arithmetic operating means **44** at an address designated upon calculation of the K value by the arithmetic operating means **44**.

When the common ratio of 1.09856 is inputted into the arithmetic operating means **44**, the K value Ky at the object distance "y" can be obtained from equation (19);

$$Ky = 100 \times (1.09856^3)^2 \approx 176$$

Since the value "Ky" is an intermediate value of the distance code plate B in a geometrical division, the object distance "y" (from the distance code plate B and the K value (Ky−y+1) at the changing point (y+1) is obtained by the following equation:

$$(Ky-y+1) = K_\infty \times (a^{y+0.5})^2$$

Consequently, when the value of (Ky−y+1) for each Ky is calculated, the following Table 7 is obtained:

TABLE 7

y	Ky	Ky−y+1
0	100	
		110
1	121	
		133
2	146	
		160
3	176	
		193
4	212	
		233
5	256	

Although the invention has been described with reference to particular means, materials and embodiments, it is to be understood that the invention is not limited to the particulars disclosed and extends to all equivalents within the scope of the claims.

We claim:

1. A camera system for communicating data between a micro computer associated with a camera body and a zoom lens that is selectively mounted to said camera body, wherein at least focal length data is transmitted from said zoom lens to said micro computer, said zoom lens comprising:

a position detecting means for detecting divided focal length steps corresponding to optional focal lengths of said zoom lens;

a specific focal length outputting means for outputting at least one focal length of a focal length step detected by said position detecting means; and,

an arithmetic operating means for calculating a focal length in each focal length step, in accordance with data representing a divided focal length step detected by said position detecting means and data representing a focal length from said specific focal length outputting means.

2. A camera system according to claim **1**, wherein said micro computer associated with camera body comprises an indication CPU and a main CPU.

3. A camera system according to claim 1, wherein said zoom lens includes a lens CPU.

4. A camera system according to claim 3, wherein said position detecting means comprises a zoom code plate that is electrically connected to said lens CPU.

5. A camera system according to claim 1, wherein said specific focal length outputting means comprises means for storing said focal length data at a telephoto extremity and outputting said stored data in accordance with need.

6. A camera system according to claim 1, wherein said arithmetic operating means comprises means for storing a common ratio for geometrically dividing a focal length range of said zoom lens into a plurality of steps.

7. A camera system according to claim 6, wherein a focal length f_x at an x-th focal length step from a telephoto extremity is obtained by the following equation:

$$f_x=f_T/r^x;$$

wherein r is a stored common ratio, and f_T is a focal length at said telephoto extremity.

8. A camera system according to claim 1, wherein said arithmetic operating means comprises means for storing a common difference for arithmetically dividing a focal length range of said zoom lens into a plurality of steps.

9. A camera system according to claim 8, wherein a focal length f_x at an x-th focal length step from a telephoto extremity is obtained by the following equation:

$$f_x=f_T-d_x;$$

wherein d is a stored common difference, and f_T is a focal length at said telephoto extremity.

10. A camera system for communicating data between a processor associated with a camera body and a lens that is selectively mounted to said camera body, said lens comprising:

a memory that stores a telephoto extremity focal length of said lens and a common ratio of said lens in accordance with said detected lens type;

a focal length calculator that calculates a focal length by geometrically dividing a focal length of said lens in accordance with said telephoto extremity focal length and common ratio stored in said memory; and

a temporary memory that temporarily stores said calculated focal length.

11. The camera system of claim 10, further comprising a lens type detector that detects a type of lens mounted to said camera body.

12. The camera system of claim 10, wherein said calculated focal length at an x-th focal length step from a telephoto extremity is obtained by the following equation:

$$F_x=f_T/r^x;$$

wherein:

f_x represents said calculated focal length at an x-th focal length step from said telephoto extremity;

r_x represents said stored common ratio at said x-th focal length step; and

f_T represents said focal length at said telephoto extremity.

13. The camera system of claim 10, wherein a focal length f_x at an x-th focal length step from a telephoto extremity is obtained by the following equation:

$$f_x=f_T-d_x;$$

wherein:

d represents a stored common difference; and

f_T represents a focal length at said telephoto extremity.

14. A camera system, comprising:

a camera body having a processor;

a zoom lens that is selectively mountable to said camera body,

a lens type detector associated with said camera body that determines what type of lens is mounted to said camera body;

a storage device that is associated with said lens that functions to essentially permanently store data representing a telephoto extremity focal length and a common ratio of said lens, in accordance with said detected lens type;

a focal length calculator that calculates a focal length of said lens that is geometrically divided correspondingly to said detected lens type in accordance with said data stored in said first storage device;

a temporary storage device that temporarily stores said calculated focal length; and

means for transmitting the temporarily stored calculated focal length to said processor associated with said camera body.

15. The camera system of claim 14, wherein said storage device and said temporary storage device comprise a single memory.

16. The camera system of claim 14, wherein said storage device comprises a read only memory (ROM).

17. The camera system of claim 14, wherein said temporary storage device comprises a random access memory (RAM).

18. The camera system of claim 14, wherein said calculated focal length at an x-th focal length step from a telephoto extremity is obtained by the following equation:

$$F_x=f_T/r^x;$$

wherein:

f_x represents said calculated focal length at an x-th focal length step from said telephoto extremity;

r_x represents said stored common ratio at said x-th focal length step; and

f_T represents said focal length at said telephoto extremity.

19. The camera system of claim 14, wherein a focal length f_x at an x-th focal length step from a telephoto extremity is obtained by the following equation:

$$F_x=f_T-/d_x;$$

wherein:

d represents a stored common difference; and

f_{Tl} *represents a focal length at said telephoto extremity.*

* * * * *

UNITED STATES PATENT AND TRADEMARK OFFICE

CERTIFICATE OF CORRECTION

PATENT NO. : 5,182,591
DATED : January 26, 1993
INVENTOR(S) : M. KAWASAKI et al.

It is certified that error appears in the above-indentified patent and that said Letters Patent is hereby corrected as shown below:

At column 16, line 67 (claim 2, line 2) of the printed patent, insert ---the--- after "with".

At column 17, line 59 (claim 12, line 6) of the printed patent, change "$F_x = f_T / r^x$" to ---f_x f_T / r^x---.

At column 18, line 47 (claim 18, line 6) of the printed patent, change "$F_x = f_T / r^x$" to ---$f_x = f_T / r^x$---.

At column 18, line 60 (claim 19, line 5) of the printed patent. change "$F_x = f_T - d_x$" to ---$f_x = f_T - d_x$---.

At column 18, line 64 (claim 19, line 9) of the printed patent, change "f_{TL}" to ---f_T---.

Signed and Sealed this

Fifth Day of November, 1996

Attest:

BRUCE LEHMAN

Attesting Officer

Commissioner of Patents and Trademarks